United States Patent [19]

Hay

[11] **3,881,340**

[45] **May 6, 1975**

[54] **DRAWING MACHINE**

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[73] Assignee: **Marshall Richards Barcro Limited,** Hampshire, England

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[21] Appl. No.: **308,748**

[30] **Foreign Application Priority Data**

Nov. 26, 1971 United Kingdom 54923/71

[52] **U.S. Cl.** **72/289**

[51] **Int. Cl.** **B21c 1/14**

[58] **Field of Search** 72/287, 288, 289, 290, 72/423; 242/79, 80, 82, 83

[56] **References Cited**

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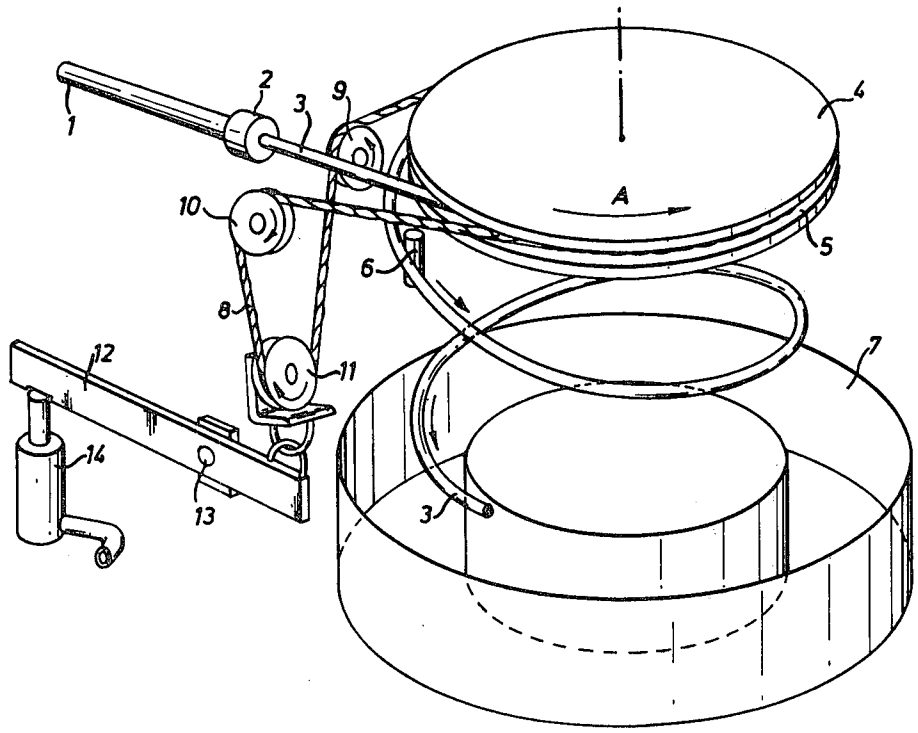
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[57] **ABSTRACT**

An improved method and apparatus for reducing the diameter and/or the wall thickness of metal tubing by generating sufficient tension in a length of tubing downstream of a reducing die to draw the tubing through the die is characterised in that the drafting tension is created by frictionally engaging the tubing in an endless groove defined by two converging surfaces and moving the surfaces and die apart at the desired drawing speed.

11 Claims, 6 Drawing Figures



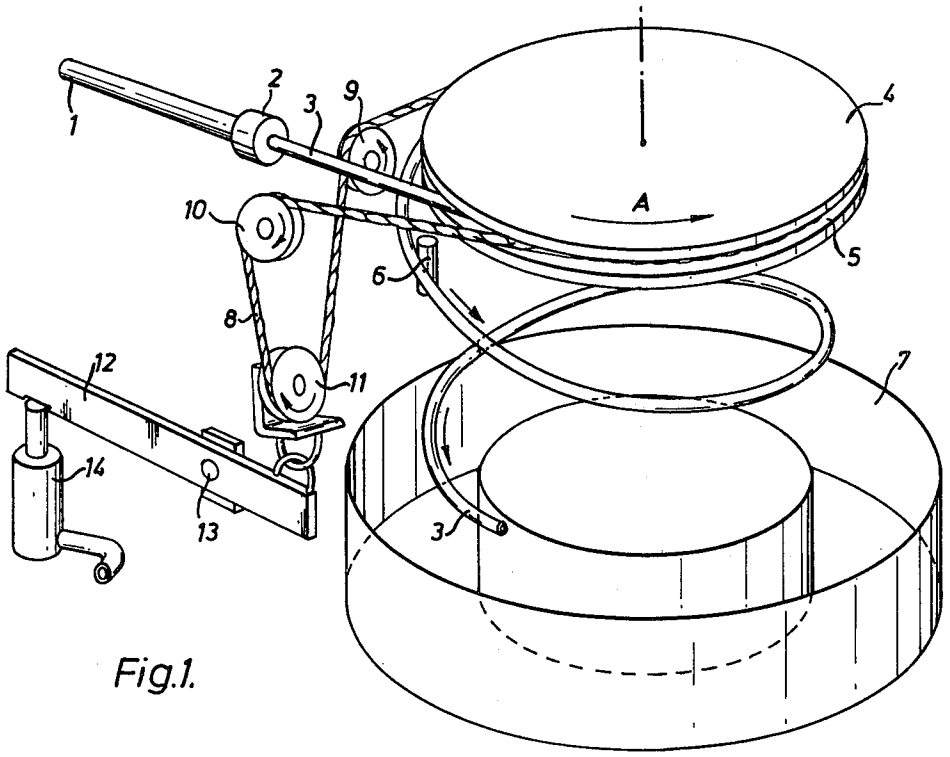


Fig.1.

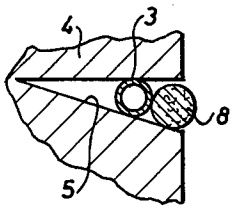


Fig.3.

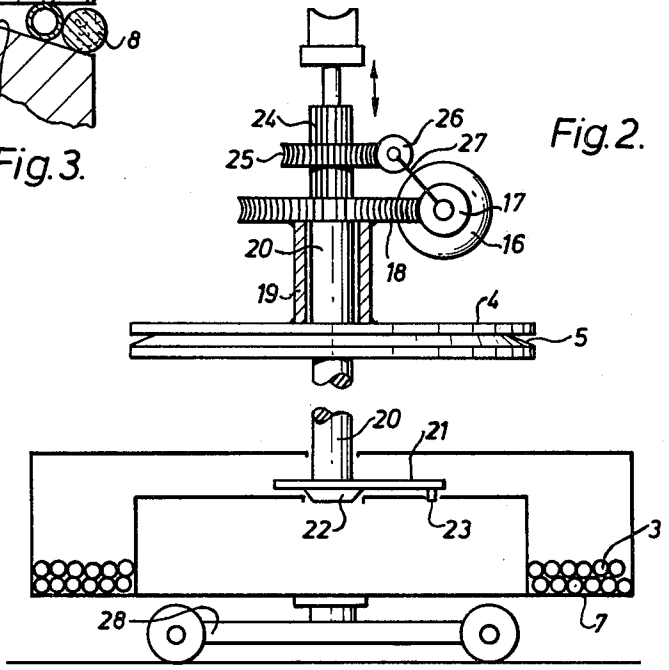


Fig.2.

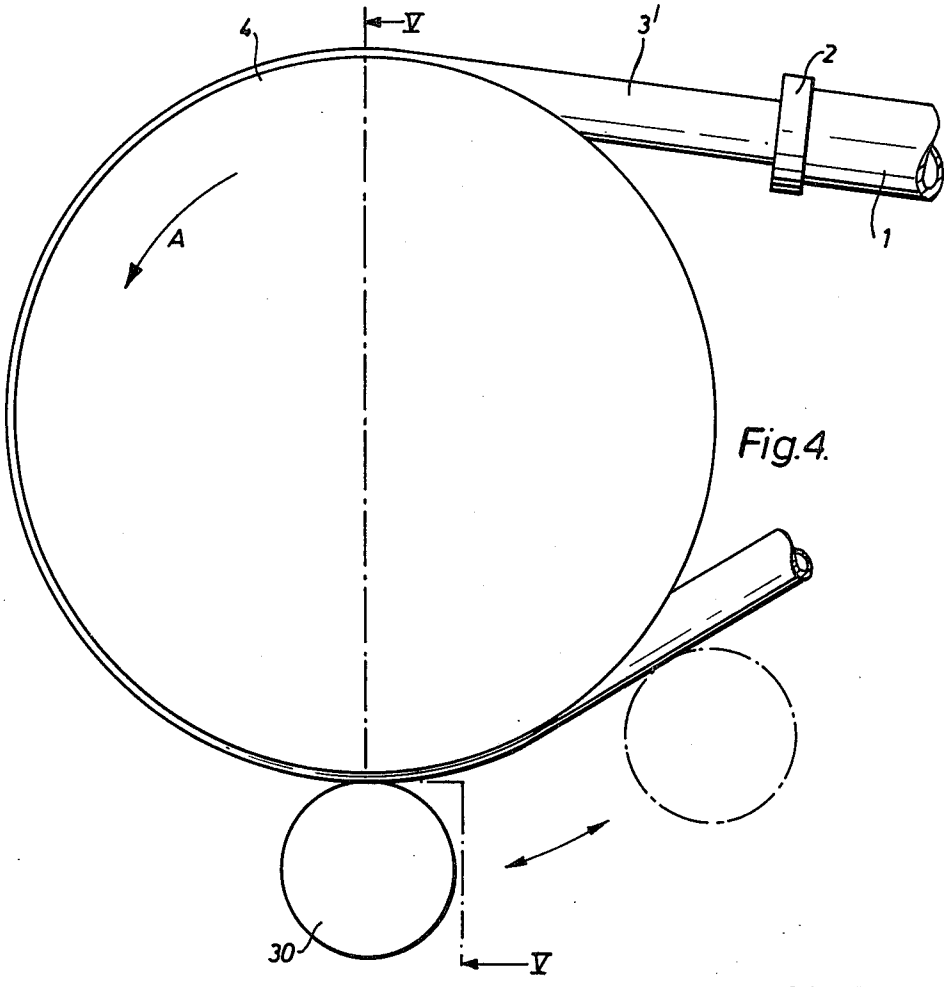


Fig.4.

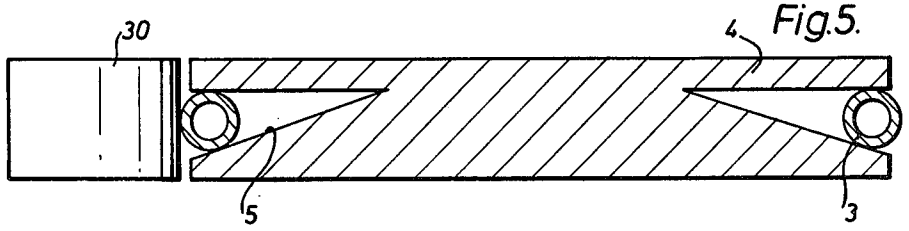


Fig.5.

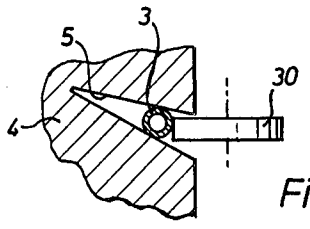


Fig.6.

DRAWING MACHINE

This invention relates to a method of drawing tubing and to an improved tube drawing machine.

It is conventional technique to reduce the diameter and/or the wall thickness of metal tubing by drawing it through a reducing die (with or without an internal plug to control the internal dimension of the tubing). In order to pull the tubing through the reducing die it is necessary to generate large tensile forces in the length of tubing downstream of the die and it has been conventional to generate these tensile forces by means of a rotating drawing block around which a plurality of turns of tubing can be disposed, a sufficient number of turns being maintained on the block to prevent "slip" of the tubing relative to the block as the latter rotates. In the case of fairly short lengths of tubing it is known to coil the entire length of the tubing, as it is drawn, on the surface of the block. Where longer lengths of tubing are under consideration, it is usual to employ a spinner block where sufficient turns (say five or six) are maintained on the block to prevent the occurrence of slip between the block and the tubing, tubing being coiled onto the block via a fleeting ring (which causes the turns to advance axially along the block) and leaving the block at the same rate at which it is coiled onto the block once steady-state drawing conditions have been attained. With both forms of prior art tube drawing machine, the tube drawing block and the ancillary equipment necessary (a) to support the tubing in its approach to the block, (b) to control the tubing on the block and (c) to collect the tubing from the block, have become more and more complicated and the cost and complexity of the machines have increased. It is now evident that some completely new technique for drawing of tubing is desirable in order to simplify the method and reduce the cost and space requirement of a typical tube drawing machine.

This invention seeks to provide such a method and such a machine.

According to one aspect of the present invention a method of reducing the diameter and/or the wall thickness of metal tubing by generating sufficient tension in a length of tubing downstream of a reducing die to draw the tubing through the die, is characterised in that the tension is created by urging the tubing into an endless groove defined by two converging surfaces with sufficient force to prevent relative slip between the tubing and the surfaces when the surfaces are moved away from the die or the die is moved away from the surfaces at the desired drawing speed.

Conveniently converging surfaces (two frusto-conical surfaces or a plane surface and one frusto-conical surface) defining an included angle of between 12° and 25° are employed and suitably these surfaces define a V-groove in the peripheral surface of a short cylindrical block.

In practice, with a block of some two feet in diameter, retaining the tubing in the groove over a circumferential distance approximating to 180° of the peripheral length of the groove has proved adequate, for drawing copper, aluminium or mild steel tubes of a wide range of different sizes.

According to a further aspect of the present invention a tube drawing machine comprises a support for tubing to be drawn, a holder for a drawing die, means for collecting tubing drawn through a die in the holder, a drawing block rotatable about an axis, the block having an endless peripheral groove formed therein defined by two surfaces converging, in the direction towards the rotational axis of the block, to a meeting plane which is normal to said axis, means to rotate the drawing block and means to hold tubing passing through the die in the groove in frictional engagement with said surfaces.

The support for tubing to be drawn would normally be a basket (or "swift") and could be of any conventional design. If the drawing of large coils is contemplated, it would normally be desirable to provide means for rotating the coil in the basket or for rotating the basket with its supported coil. Thus for example, power driven rollers can be provided to define an annular recess in which the coil can be supported, the rollers being powered to rotate the coil within the basket and minimise strain on the tubing prior to its passing through the die.

Conveniently, the means for collecting the tubing drawn through the die comprises a pan or basket designed to be rotated with the block. Preferably, the pan or basket is driven from the same means employed for rotating the block but with the interposition of a variable speed drive so that the actual rate at which the pan or basket is rotated can be set, relative to the rotational speed of the block, to allow for the fact that the tube shed from the block has a radius of curvature which is different from the radius of the block.

The drawing block can have its rotating axis in any direction but there are advantages in this being vertical or inclined slightly to the vertical. In operation of the machine, before the tubing has made one complete turn around the block within the groove, it must leave the groove and there may be advantages in inclining the rotating axis of the block at something between 5° and 30° to the vertical to facilitate the removal of the tubing from the groove. Preferably the groove is V-shaped and, in any radial cross-section, is defined by converging straight lines. The upper of the two surfaces may be inclined downwardly towards said meeting plane, may lie in the meeting plane and, in some circumstances, may be upwardly inclined towards the meeting plane. The lower of the two surfaces is preferably always upwardly inclined towards said meeting plane.

A drawing block machined from mild steel with a turned outer surface is perfectly acceptable although normally at least the region of the block defining the groove will be hardened. It may be desirable to coat the surface of the block defining the groove with a thin coating of a resilient material (e.g. a synthetic plastics material).

In order to employ one block for a plurality of different drawing operations on tubing of different external diameter it may be desirable to provide more than one groove and suitably three concentric grooves of different groove cross-section can be provided, one above the other, these grooves either having the same radius relative to the axis of the block or having a radius which decreases from groove to groove in the downward direction of the block. This arrangement enables early passes to be drawn using the groove of largest radius and groove cross-section, middle passes using the medium sized groove and the latter passes using the groove of smallest radius and groove cross-section.

In place of a plurality of axially-spaced grooves in the drawing block, a single groove may be provided whose

groove cross-sectional size is adjustable. This adjustable feature can be provided by making one of the surfaces defining the groove movable relative to the other surface.

Normally the die holder is positioned so that it is substantially axially aligned with the groove into which the tubing passes and where a plurality of grooves are provided spaced-apart in the axial direction of the block it may be desirable to mount the die holder so that it can be moved to align the axis of a die housed therein with the particular groove being used.

The means for holding the tubing into the groove can be an endless belt of flexible substantially non-extensible material and a loop of rope of natural or synthetic fibres has been found suitable. Suitably the loop of rope passes around a path defined by three pulleys and some 270° of the total circumference of the block. One of the three pulleys may be connected to a hydraulic motor which acts to move that pulley in a direction to increase the size of the loop path available to the rope whereby this hydraulic motor can be used for tensioning the rope to provide sufficient force on the tubing to hold it in the groove, particularly on start-up. In place of an endless belt, one or more rollers may be used either to physically press the tubing into the groove or to define a departure path for the tubing from the groove which results in the tubing being held firmly in the groove, over a length upstream of the roller. This latter method is only suitable in the case of a reasonably rigid tube (e.g. mild steel).

The total enclosed angle between the converging surfaces defining the groove is suitably between 12° and 25°, preferably in the range 17° to 22°.

We have found that a reduction of external cross-sectional area of the order of 20 percent in copper tube having an initial external diameter of 0.460 inch (11.7 mm) and a wall thickness of 0.017 inch (0.4 mm) can be achieved with a V-groove of a total included angle of 17° if a length of between 30 and 40 inches of the drawn tubing is held in the groove. There is no need to remove lubricant from the tubing before it enters the groove and it has not been found necessary to specially treat the surfaces defining the groove.

Conveniently the block is provided with a pulling-in "dog" (of any conventional type) which is used to start a drawing operation on a new coil of tubing. A pointed end may be formed on the leading end of the new coil of tubing in any conventional manner, this pointed end permitting easy passage through the die for a length sufficient to enable the leading end to be gripped by the "dog." The "dog" can then be moved away from the die (e.g. it may be attached to the block) so that the first part of the turn of the block draws tubing through the die until a sufficient length is available to enable it to be locked in the groove. An alternative method of "threading up" involves fixing the "dog" relative to the frame of the machine and moving the die box away from the "dog" to draw an initial length which is sufficient for locking within the groove. The leading end can then be released from the "dog" and the die moved forward again to the position it will adopt during the following drawing operation as the leading end of the tubing is lapped around the block and located in the groove.

Although an arrangement in which the block rotates adjacent to a relatively stationary die is preferred, the converse arrangement of a stationary block and a die assembly rotating about the axis of the block is also possible.

Embodiments of tube drawing machine in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

FIG. 1 is a schematic perspective view of some parts of one form of drawing machine,

FIG. 2 is a schematic side elevation of the machine of FIG. 1 showing how the drawing block and an associated basket for collecting drawn tubing can be driven together from a common drive motor,

FIG. 3 is a scrap sectional view of part of the block of the machine of FIG. 1,

FIG. 4 is a schematic plan of parts of a modified form of machine,

FIG. 5 is a schematic sectional side elevation of the block of FIG. 4 shown on the line V—V, and

FIG. 6 shows a still different arrangement for holding tubing in the groove of the drawing block.

Referring to FIG. 1, the machine comprises means (not shown but to the left) for supporting a coil of tubing 1, a length of the tubing 1 being shown leading to a die 2 through which drawn tubing 3 passes to a rotataing cylindrical drawing block 4. A V-groove 5 is formed in the peripheral surface of the block 4 and the tubing is trapped in this groove and rotates with the block 4 in the direction of the arrow A. After less than one complete turn around the block 4, the tubing leaves the groove (it is urged out by a guide 6) and falls down into a suitable collecting basket 7.

To hold the tubing 3 within the groove 5, with a sufficiently strong radially directed force to prevent slip between the tubing and the groove, and to generate the desired drafting force to pull the tubing 3 through the die 2, an endless loop 8 of non-extensible flexible material is provided, which loop is defined, in part, by the peripheral surface of the block 4 and in part by pulleys 9, 10 and 11. Peripheral regions of the pulleys 9 and 10 are substantially in the median plane of the groove 5, but pulley 11 is either above the median plane or (as illustrated) below the median plane of the groove. A lever 12 pivoting about an axis 13 supports the pulley 11 and is urged in a direction to tension the loop 8 by a ram 14.

FIG. 2 shows a simple arrangement in which a motor 16 drives a worm 17 meshing with a pinion 18 which is fast on a hollow shaft 19 of the block 4. Passing through the shaft 19 is a rod 20 which at its lower end supports a drive plate 21 having a central locating pad 22 and an eccentric spigot 23. The upper end of the rod 20 is splined at 24, the splines interengaging with similar splines on a further pinion 25. The pinion 25 is engaged by a second worm 26 and a variable speed drive (shown schematically by the line 27) interconnects the worms 17 and 26.

Located below the block 4 is the basket 7 and this is rotatably mounted on a trolley 28. The pad 22 serves to ensure central location of the basket 7 with respect to the block 4 and when the rod 20 is lowered (after an empty basket has been positioned below the block 4), the spigot 23 engages in a drive opening in the upper part of the basket 7 and causes the basket to rotate in the same sense as the block 4 and at a speed pre-set by the drive 27 with reference to the speed of the block 4. Thus the tubing 3 leaving the groove 5 in the block 4

drops downwardly into the basket 7 and is collected there.

FIGS. 3 to 6 show a variety of different ways of ensuring that the tubing is retained within the groove 5 over an arc of sufficient length to generate the desired drafting tension. FIG. 3 shows the arrangement illustrated in FIG. 1 where an endless loop 8 is employed. FIGS. 4 and 5 show how at least one roller 30 can be used in place of the loop 8,7 the roller being positioned so that it does not enter into the groove. The position of the roller 30 can be varied (e.g. between the position shown in full line in FIG. 4 and the position shown in dashed line) but normally the roller 30 (or the last roller 30) would be at least 180° round the block from the position at which the tubing 3' first contacts the block. FIG. 6 shows a modified use of rollers, this time the rollers being narrow enough to enter into the groove. In the case of tubing with an adequate resistance to bending, a roller (such as roller 30) can be employed which is outside the groove 5, but in this case the roller is positioned downstream of the point at which the tubing leaves the groove. The roller or rollers used for the arrangements shown in FIGS. 4 to 6 may be mounted on support arms movable towards and away from the block. Rams or the like can be employed to move the rollers and where a plurality of rollers are used they may be ganged together and controlled by one ram.

One example of a drawing operation in accordance with the method of the invention is illustrated by the following Example. The block 4 had an outside diameter of 26 inches (660 mm) and a V-groove of included angle 17°. The block was rotated by a 45 kw DC motor at a speed which could be controlled by means of a Ward Leonard set. A 1½ inch circumference polyester rope (i.e. a rope made from the material known by the Trade Mark "Terylene") was formed into a closed loop 8 and a coil of copper tubing having an outside diameter of 0.373 inch (9.47 mm), an inside diameter of 0.341 inch (8.66 mm) and a wall thickness of 0.016 inch (0.40 mm) was passed through a drawing die having a circular aperture of 0.245 inch. The leading end of the tubing was trapped between the rope and the groove of the block and was held in the groove around an arc of 230°. Tension of the order of 30 lbs force was maintained in the rope. A drafting tension of 650 pounds force was generated in the tubing when the block was rotated and the tube was drawn (as a sink pass) to give rise to a drawn coil having an external diameter which was 0.245 inch measured in the direction parallel to the axis of the drawing block and was 0.249 inch in the direction normal to this (i.e. an ovality of 0.004 inch). A drawing speed in excess of 1500 feet per minute was achieved without difficulty and the tension in the rope could be drastically reduced when steady-state drawing conditions had been attained.

The advantages of a rotary tube V-block for drawing tubing when compared with a conventional capstan block machine are very considerable. Making a comparison between a machine in accordance with the present invention and a spinner block-type of machine the following considerations arise: 1. The pay-off basket (or swift) used to support the coil to be drawn will not have to be lifted to such a great extent as is required with a spinner block since the die holder in a rotary tube V-block machine (RTV) remains at a sensibly fixed position. This greatly reduces the cost of the pay-off basket in an RTV machine. 2. The block in an RTV machine is very much smaller (a few inches in axial length as opposed to a few feet in a spinner block) and is therefore much cheaper and easier to mount. There is no need to provide expensive block-positioning equipment in an RTV machine as is the case with a spinner block. 3. In a spinner block it has been customary to mount both the tube shear (for separating the leading end of the tubing from the "dog") and the pulling-in "dog" on the block and to provide these with power supplies which have to pass through the rotating shaft of the block. With an RTV machine these components do not have to be provided on the block and consequently expensive rotating seals are avoided as are the expensive mechanism required for moving the "dog" to and from its working position. 4. On an RTV machine there is no need for the fleeting ring required on a spinner block and this represents a considerable cost saving. 5. The large hold-down rollers necessary on a spinner block are not required on an RTV machine and although an arrangement has to be provided for holding the tubing within the groove of the RTV machine this can be much simpler than conventional hold-down rollers. 6. A marked saving on the overall size of the machine is possible. In both block diameter and axial length, an RTV machine is considerably smaller with consequential economies in overall cost. 7. During the operation of an RTV machine less than one turn is supported on the block at any one time so that at the end of a drawing operation only one turn has to fall from the block, this turn normally being adjacent to the bottom of the block. This eliminates the danger experienced with a spinner block (where five or six turns will drop from an axially longer block at the end of the drawing operation) that damage will be done to the tubing as it leaves the block. 8. An RTV machine can be used for recoiling tubing to coils of smaller diameter than is customary with a spinner machine. This recoiling can be accomplished during a drawing operation or simply as a recoiling operation without any change in cross-section of the tube provided some tension is created in the tubing approaching the block by passing it, for example, between killing rolls. 9. When tubing is wrapped around a cylindrical block some ovality of the cross-section of the tubing will result due to the bending, the major axis of the oval shape being parallel to the axis of the block. Pressing tubing into a groove tends to produce an oval cross-section, the major axis of the oval being parallel to the median plane of the groove. Thus when drawing tubing on an RTV machine the tendency for the tubing to become oval due to being bent around the block can be counteracted by the squeezing effect of the groove resulting in drawn tubing with no ovality. The groove angle has been found to affect the ovality produced by the "squeezing effect" and the optimum groove angle will be a function of block diameter, the diameter of the cross-section of the tubing and the wall thickness of the tubing. In practice a groove angle can be chosen which is a compromise for the various tubing sizes to be drawn on a block. Residual ovality with the major axis in the direction normal to the centre line of the block will be reduced (or completely removed) when the tubing is subsequently fed between straightening rolls. Thus tubing with a low degree of ovality can be a feature of material drawn on an RTV machine.

I claim

1. A method of reducing the diameter and/or the wall thickness of metal tubing by generating sufficient tension in a length of tubing downstream of a reducing die to draw the tubing through the die, characterized in that the tension is created by urging the tubing into a convex groove section of an endless groove defined by two converging relatively acutely inclined wedging surfaces to releasably wedge the metal tubing therebetween with a sufficient radial force substantially less than and established independently of the drawing tension to prevent relative slip between the tubing and the wedging surfaces when the endless groove and the die are relatively moved at the desired drawing speed and relatively moving the die and endless groove to draw the metal tubing through the die.

2. A method as claimed in claim 1, in which the groove is defined in the peripheral surface of a cylindrical drawing block.

3. A method as claimed in claim 2, in which the groove is provided by converging surfaces defining an included angle in the range between 12° and 25°.

4. A method as claimed in claim 2, in which the tubing is retained in the groove over a circumferential distance around the block of at least 180° as subtended at the centre of the block.

5. A tube drawing machine comprising a support for tubing to be drawn, a die holder, a drawing die mounted on the die holder, means for collecting tubing drawn through the drawing die in the holder, a drawing block rotatable about an axis, the block having an endless peripheral annular groove formed therein defined by two annular wedging surfaces converging at an acute angle, in the direction towards the rotational axis of the block, to a meeting plane which is normal to said axis, for wedging the tubing therebetween, means to rotate the drawing block and means separate from the tubing and operable independently of the drawing tension to hold tubing passing through the die in less than 360° of the groove in frictional engagement with said wedging surfaces.

6. A tube drawing machine as claimed in claim 5, in which the groove is V-shaped and, in any cross-section in the radial direction of the block is defined by converging straight lines, the angle between the lines being between 12° and 25°.

7. A tube drawing machine as claimed in claim 6, in which the upper of the two surfaces lies in the meeting plane, the lower surface being a frusto-conical surface inclined upwardly to define a groove of internal angle between 17° and 22°.

8. A tube drawing machine as claimed in claim 5, in which a flexible endless belt is used to hold the tubing in the groove.

9. A tube drawing machine as claimed in claim 5, in which at least one roller is used to hold the tubing in the groove.

10. A tube drawing machine as claimed in claim 5, in which a basket is provided below the block for collecting tubing shed from the block, the basket being mounted so that it can be rotated about the axis of the block, and means is provided for rotating the basket at a speed related to the speed of rotation of the block.

11. A method of drawing thin wall metal tubing having a generally circular cross section with a rotatable drawing block and at a predetermined tension without substantially deforming the circular cross section of the metal tubing, comprising the steps of providing a drawing block with an endless peripheral annular groove defined by two opposed annular wedging surfaces converging at a predetermined relatively acute angle toward the rotational axis of the drawing block for releasably gripping the tubing, without enlarging the cross sectional dimension of the tubing in the direction parallel to the axis of the drawing block, as the tubing is drawn under the predetermined tension into frictional engagement with the wedging surfaces and around a section of less than 360° of the annular groove as the drawing block rotates, rotating the drawing block to draw the tubing into the peripheral groove in frictional engagement with said wedging surfaces, and maintaining the tubing in frictional engagement with the wedging surfaces along said annular section of less than 360° and urging the tubing into said annular section with a radial force, substantially less than and established independently of the drawing tension, sufficient to prevent slip between the tubing and the opposed wedging surfaces.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,881,340

DATED : May 6, 1975

INVENTOR(S) : ROBERT THOMAS VERNON HAY

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 25, delete "taing" and insert --ting--.

Column 5, line 9, delete "7".

Column 7, line 6, after "convex" delete "groove".

Column 7, line 6, after "endless groove" insert --wherein said groove is--.

Signed and Sealed this

thirtieth Day of *September 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks